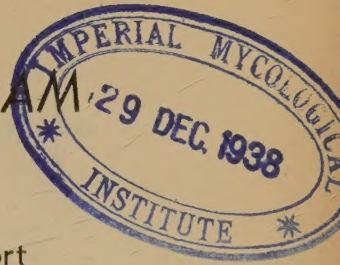
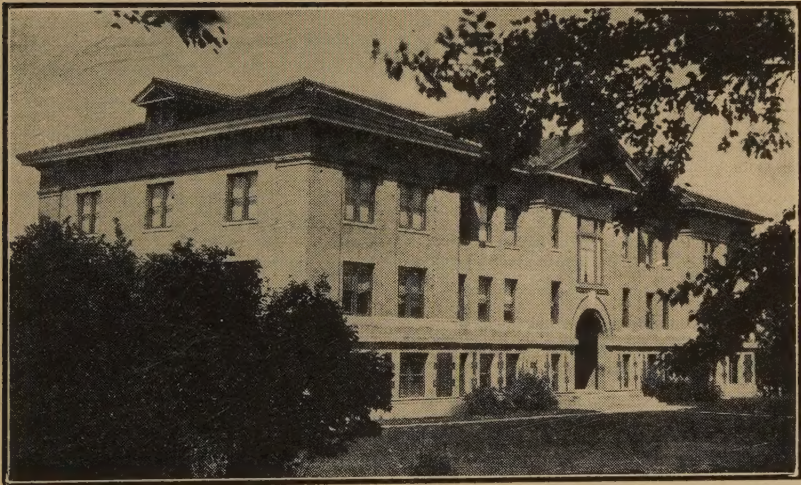


A RESEARCH PROGRAM



The Forty-third Annual Report
of the
Montana Agricultural Experiment Station
July 1, 1935 to June 30, 1936



MONTANA STATE COLLEGE
AGRICULTURAL EXPERIMENT STATION
BOZEMAN, MONTANA

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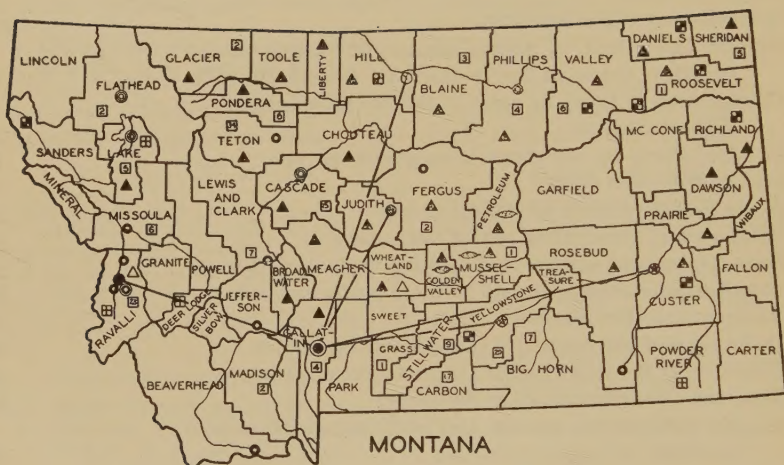
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¹Organization as of November 30, 1936.

²Cooperating with the United States Department of Agriculture.

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| ● BRANCH STATIONS & U.S.D.A. COOPERATING | ▣ FERTILIZER EXPERIMENTS |
| ● U.S.D.A. FIELD STATIONS & MONT. AGR. EXPERIMENT STATION COOPERATING | ▣ FAIRWAY FARMS |
| ● ENTOMOLOGY FIELD EXPERIMENTS | ▲ COUNTY SOIL SURVEY |
| ● HORTICULTURAL FIELD EXPERIMENTS | ▲ BOTANICAL FIELD EXPERIMENTS |
| | ◀ LAND UTILIZATION & REORGANIZATION STUDIES |

The activities of the Montana Agricultural Experiment Station are state wide.

Note the various counties of the state where work is being carried on.

CORRECTIONS

Page 20, line 13—heifers gained 1.17 pounds.

Page 52, line 6—755 pages.

Page 53, Annual Report—3500 copies, 56 pages.

A Research Program

BY THE DIRECTOR

Montana can look back through three periods of settlement. Those white men who first came to the area now included in Montana were the explorers and trappers, transient visitors, few of whom remained. The first real settlers came with the gold seekers and the miners who built communities and established local civil governments. They started an industry which, while it has changed, yet has very largely developed and expanded through the years.

The next large group that came to the state were the stockmen, first with cattle, then with sheep. They too built centers of civil government, but in the range country, thus supplementing and broadening the base of settlement in the state.

The first farm settlers were mainly a backwash from those who came to seek their fortunes in the mining and livestock industries. These people developed the early irrigation farming of the state. To a large extent their produce for many years found a local market.

The second wave of settlement to the farming lands grew out of the dry farming propaganda during the latter part of the last century and the beginning of this. The result was to essentially double the population of the state in a few years and to so increase agricultural production as to make imperative the dependence of the farmers of Montana on the national markets, while this also determined largely the price they received.

The coming of these new settlers and their farming experience through the passing years, resulted in the accumulation of much knowledge and understanding about what crops could be grown in the various parts of the state on both the dry land and in the irrigated areas. From this experience much has also been learned about the limitations on agriculture imposed by lack of precipitation, by the dry, hot winds, and the extremes of temperature over nearly all parts of the state. Much has also been learned of the average dependability and availability of the agricultural resources of the state. These experiences have been supplemented by various research agencies and for agriculture especially by the work of the Agricultural Experiment Station.

Coupled with the experiences which nature and the environment have brought, we have during the past 20 years experienced extreme fluctuation and changes in the economic field. At times large expansion in production has been encouraged due to inflated prices, later to be followed by equally great extremes in reduced demand for agricultural products, accompanied by drastic reduction in prices. This occurred through a long drawn out and very severe national depression, which for the farmer extended from 1921 to the present time.

We must next remember that the new settler came to Montana only a few years before this period and staked his limited resources in an attempt to develop a farming enterprise in a new and agriculturally untested country. Moreover, the fact must not be overlooked that he had at the same time to contend with the extreme of weather and the changing economic factors. The consequences of these extremes in experience measurably resulted from our ignorance, as little or no attempt had been made by the state or nation, or by private enterprise to definitely study what the state had to offer agriculturally. It was known that certain areas were growing good crops but about vast areas of the state, into which new settlers moved, practically nothing was known and there was but little planning to try and find out. Had we known more, and thus been able to advise intelligently, many mistakes could have been avoided. This ignorance, however, was not alone personal or institutional, but it was also community, state, and national. Measurably, perhaps, these results may also have been because we did not or would not use fully what little knowledge we had.

With the past experience behind us, would it not appear that another turning point in the Station work has been reached when we could go forward with a new vision of the agricultural problems of the state? Should we not now be much better prepared to plan and build a better, a safer, and a more dependable agriculture? This can be done if all the people of the state will aggressively take hold of the task.

The Agricultural Experiment Station is assiduously studying the experience and the records of the past and the evolution occurring up to the present, so that the base for the new start may be as safe and solid as it can be made considering the yet limited available facts. As knowledge of the problems increases, the hope

is to strengthen this base and better visualize the superstructure which the future may construct.

The Station work is foundation laying, adding new facts as they are discovered and by careful analysis and thorough study of these facts to broaden and deepen the understanding of the science and practice of our agriculture. Discovering new truths may be, and generally is, a long drawn out undertaking. Not days or months but generally years are necessary, while the full measure of the application of these discoveries may take yet many other years. Ample financial support and persistent effort along the chosen lines of research is all important if the deeper truths in agricultural science are to be discovered even by the best qualified men, of which the Agricultural Experiment Station is able to employ all too few. Some of these foundation facts dug out by the Montana Station are presented in this report. It is in this setting that this agricultural research institution will best serve the agencies for instruction in both the College and the Extension fields and in the development of the state.

ECONOMIC RESEARCH FOR THE FARMERS OF MONTANA DEPARTMENT OF AGRICULTURAL ECONOMICS

The Department of Agricultural Economics is studying the various economic problems as they affect the farmers of Montana, but its studies also extend to the economics of several services and programs as they affect the communities, the counties, and the state during an evolving and changing period. It is fully recognized that agricultural production is modified by weather conditions to which the farmer must adapt his farm practices if he is able to produce at all, and also by the kind of soil and the availability of water.

There are, too, limiting factors which are economic in character, such as market possibilities, which are again modified by the quality of the product. Yet other economic factors to be considered are the methods of organization and management possible on farms if production cost is to be kept to a minimum and relative to those of other farm areas.

Farm and Ranch Management and Organization

The field of farm and ranch organization and management study during the past few years has been largely concentrated in

the dry land areas, and the study has been intensified because of the extreme drought and the low prices for agricultural crops.

The Department has carried on considerable studies to determine the most economical operating units for both dry farm and range lands. These studies indicate that for the dry farming lands the majority of the farms are too small for most efficient operation. In an analysis of the farm organization of grain and combination grain and livestock farms in 17 counties, covering the period 1928-1935, it was found that 636 operators, or 7.2 per cent of the total, had operating units of 160 acres or less; 2136 operators, or 24 per cent of the total, had operating units from 161 acres to 320 acres; 1179 operators, or 13.3 per cent of the total, had operating units of from 321 to 480 acres; and 1592, or 18 per cent of the total, had acreages of from 481 to 640 acres. In other words, in these 17 counties in a fairly representative dry farming area, a total of 62½ per cent of the farms consisted of one section of land or less, nearly a third of these having a half section or less.

The Station studies on the costs of production indicate that 800 acres is about the proper size for a family with a four-plow tractor and corresponding farm equipment when farmed, on an alternate summer fallow wheat rotation system. In other words at least two out of every three of the farmers in these 17 counties have farms too small for economical grain production.

Along with the analysis of acreages in these 17 counties, an analysis was also made of the gross income distribution of these farms. It was found that during the period 1928-1935, inclusive, 65 per cent of the farmers in this area had gross incomes of \$2000 or less, and another 26 per cent had gross incomes of from \$2001 to \$5,000. In other words, two out of every three of these farmers had gross incomes of but \$2000, which for many of them would probably net not more than \$100 annually. Seventeen per cent of the farmers in the area had gross incomes of \$500 or less, and 21 per cent had gross incomes of \$501 to \$1000, which meant a very small net income to support a reasonable standard of living and enable them to pay reasonable costs for community services such as schools, roads, and the like. If Montana is to maintain her place in grain production, larger operating units would seem to be one solution. However, other problems associated with increasing size of operating units cannot be ignored, as Montana already has prob-

lems growing out of sparse population and a relatively heavy cost for community services, particularly for roads and schools.

If some families move out of any areas, the fewer families left will have more nearly the proper size operating farm units. Research is now being carried on by the Economics Department to secure more information on Montana farm population characteristics, so that if these families move to other areas each will then be rehabilitated in a way most nearly adapted to their abilities and interests. An adjustment possible is for these farms to add certain range areas for pasturing of livestock during the summer. If they are associated with a neighboring grazing district, described later in this report, the problem of the care of their livestock would be simplified. The farm should provide a measure of winter feed. The situation presented would also be helped by the development of irrigation so that supplementary feed supplies will be available, thus permitting the proper number of livestock to be carried with less range acreage than would be required on a straight range basis. On this point research is now being carried on.

The Problem of the Ranch

A range economic survey was made by the Montana Experiment Station Department of Agricultural Economics, in cooperation with the Bureau of Agricultural Economics, U. S. Department of Agriculture, during the summer and fall of 1936 to determine the problems range stockmen were encountering in their operations and to offer possible solutions. Ranchers, operating all sizes of ranches and under all types of land ownership and conditions, were personally interviewed. Some of the more significant results of this survey are as follows:

There was a general acceptance by the ranchers that their range was not as good as when they first began their ranching operations. The principal cause for this was said to be drought. Lack of control of their range was also stated as one of the principal reasons for range depletion, and such lack of control was given as the main reason for not attempting to improve the range. More conservative use of the range was considered desirable by the majority of the stockmen interviewed; they felt that 75 per cent utilization of the normal grass crop would result in range improvement, and help to stabilize their ranch operations. Many, however, were doubtful whether they could carry out such a practice.

Stock water development was most favored as a means of range improvement. However, there appeared to be little knowledge about, or practice of, such range improvement proposals as deferred and rotation grazing, contour furrowing, etc.

Grazing Districts.—A serious problem with which the ranches in Montana have to contend is how to control the use of the range.

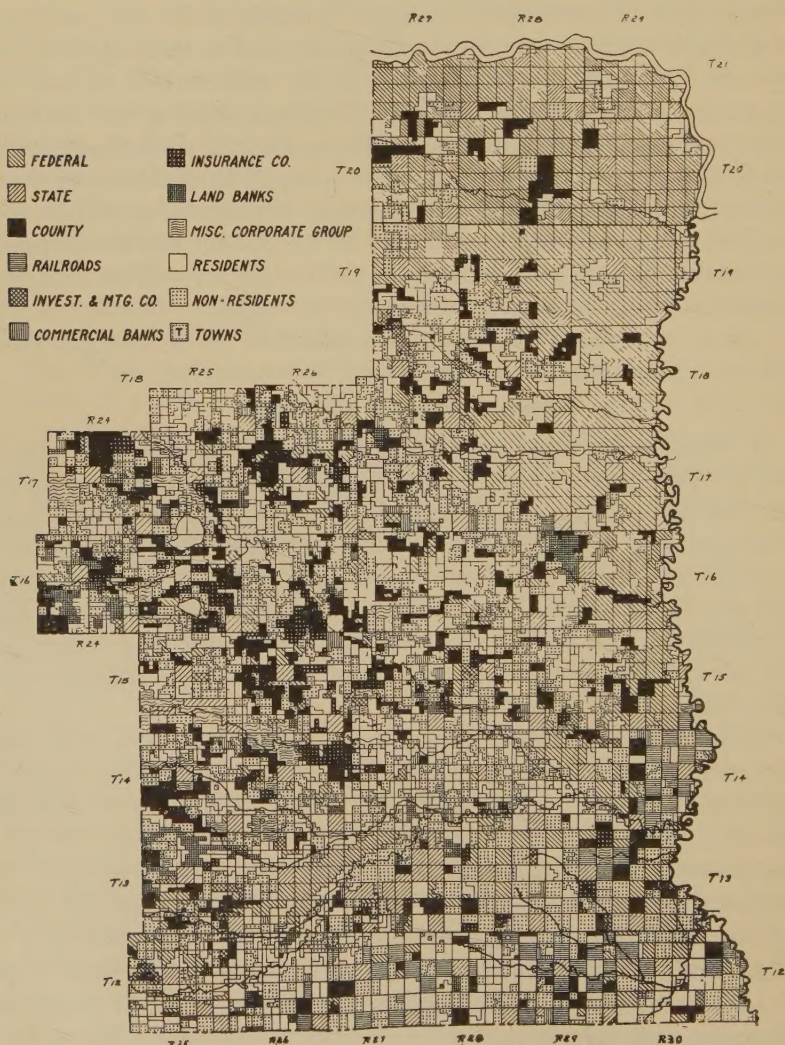


Figure 1. Ownership map of Petroleum County

The increase in number and area of state grazing districts results partly from the possibilities these organizations hold out for solving this and other problems in range land utilization. Figure 1 shows a typical land ownership pattern in the eastern two-thirds of Montana. The cooperative state grazing districts in the county are shown in figure 2. These districts have been organized during the last two years. Through this procedure is made possible control of range lands by long time leases or by actual ownership. The cooperative leasing of land eliminates the necessity of com-

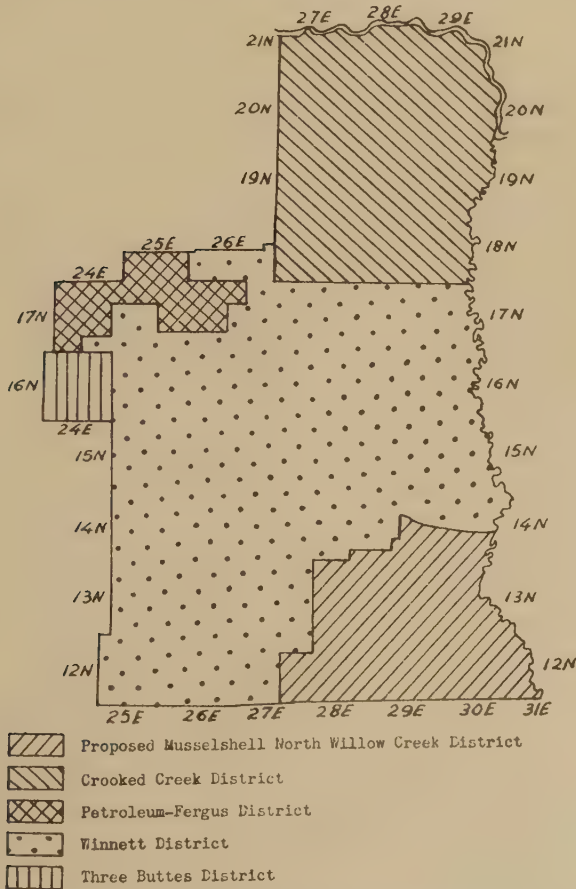


Figure 2. State grazing districts in Petroleum County, Montana, July 15, 1937

petitive bidding among the ranchers in the area, and should help reduce land charges. With control of the range assured, grazing districts can formulate plans for the proper use and improvement of the range. The ability to control all types of land ownership and administer the grazing on these lands offers considerable assistance to adjustments in land utilization.

A good start has been made in Montana on working out this community range control problem, but much study and planning for more permanent control of the area within the district is needed and this Department is cooperating on this study.

Taxation and Government

The research on taxation and local government carried on by the Department has been directed principally toward (1) the methods of increasing efficiency of local government and thereby reducing the farm tax burden, and (2) changes in the assessment system to make it more scientific, so that farm tax burdens would be based more largely on ability to pay.

Under the first heading, considerable research has been done to determine the factors which make for high cost per unit of services rendered by county governments and school districts, and the results have been published in Buletins Nos. 298 and 325.

In the study on the changes needed to make the assessment system more scientific, so that the farm tax burdens will be based more on ability to pay, considerable research has indicated that a productivity value base for the different grades of farm and range lands is desirable. With the aid of farm and range cost account records, and the soil classification made available through the soil survey studies, the productivity or longtime average valuations of the different grades of farm and range lands have been determined. These values are based on the longtime average price of grain and livestock and prospective operating costs.

Values that have been determined for the different grades of *grazing land* are first grade, \$3.00; second grade, \$2.50; third grade, \$1.50; fourth grade, \$1.00; and fifth grade, \$0.75 per acre. The productivity values of *dry farm crop lands* were found to be the following: first grade, \$35; second grade, \$18; third grade, \$3; and fourth grade, \$1.50 per acre.

Studies of assessed valuations of lands in sample areas of the state showed that the better grades of farm land are distinctly

under-assessed from the standpoint of their productivity or their capitalized expected earnings value, while the poorer grades of farm land and all grades of range land are decidedly overassessed. The relationship of assessed value to productivity value for the different grades of land, under present assessment basis, is as follows:

Farm Land

Assessed value of First grade farm land is .46 times the productivity value.

Assessed value of Second grade farm land is .58 times the productivity value.

Assessed value of Third grade farm land is 3.25 times the productivity value.

Assessed value of Fourth grade farm land is 4.08 times the productivity value.

Grazing Land

Assessed Value of First grade grazing land is 4.21 times the productivity value.

Assessed value of Second grade grazing land is 2.36 times the productivity value.

Assessed value of Third grade grazing land is 4.11 times the productivity value.

Assessed value of Fourth grade grazing land is 5.12 times the productivity value.

Assessed value of Fifth grade grazing land is 7.80 times the productivity value.

The determination of reasonable productivity or capitalized expected earnings values for the different grades of Montana land should be of great value in working out a sound agricultural program. Taxes and interest on mortgages and other credit carried by the farmer are extremely important items because of their rigidity. A scientific basis for determining what farm and range lands are really worth should be of value to all those in any way interested in farm values. Tax and credit policies, when based on these productivity values, will be a very large factor in establishing in the future a more stable agriculture. Tax deeds and mortgage foreclosures have been serious disturbing factors in Montana agriculture in the past, affecting in turn the land ownership and tenure pattern and the whole problem of overgrazing and improper dry farming practices leading to soil erosion and soil blowing.

**CROP ADAPTATION, CROP AND SOIL IMPROVEMENT
DEPARTMENT OF AGRONOMY**

The research work of the Agronomy Department with crops covers mainly projects in a crop adaptation and improvement, soil enrichment and weed control.

I. *Crop Adaptation*: Projects involve mainly variety tests with (1) wheat, both winter and spring; (2) oats; (3) barley; (4) rye; (5) flax; (6) alfalfa; (7) grasses, and miscellaneous crops. In the tests the measure of value is not alone high yields but the development of varieties resistant to extremes of temperature, both winter and summer; to diseases which prevail in Montana; and to drought. The modern crop variety must also have high quality. What is desired in a winter wheat, for instance, is a bearded, stiff-strawed variety which is immune or highly resistant to stinking smut and other diseases; which will survive low winter temperatures, will stand up under hot and dry weather and will yet produce a high yield of excellent quality wheat which will command the best market price.

The original supply of seed for these studies comes from winter-hardiness nurseries conducted at over 20 points in the United States and Canada for a long period of years. These nurseries point out certain varieties which are superior in ability to resist extremes of winter temperature, while varieties grown on rich, irrigated soils demonstrate the stiffness of straw. Then seeds of each variety are artificially inoculated with stinking smut and grown where this disease will develop at its best, and those susceptible to this or any other serious diseases are discarded. Again the varieties unable to withstand the dry hot weather, in the dry land areas of the state, are eliminated. Finally tests determine the varieties which will have a strong market demand. Thus, slowly, through this series of exacting tests carried through several years, the most promising varieties for the conditions in question are determined.

II. *Crop improvement* is the task of the plant breeder who selects promising parent materials which are crossed, to combine in the progeny as many as possible of the characters desired. In succeeding years these progeny are increased in the field plots and by means of field and laboratory tests the undesirable types are weeded out and the better and more promising types are sub-

jected to the same tests as in the studies on crop adaptation. This is generally a long time process.

III. *Soil improvement* methods are studied to maintain by physical and chemical means the soil's productive ability. The irrigated crop rotations at Bozeman have demonstrated very clearly that a rotation of wheat, potatoes and barley, followed by 3 years of alfalfa will produce much larger yields of the cereals and potatoes than has been obtained when these three crops have been grown in a rotation without the alfalfa. This and other rotations continued through the years with and without special fertilization, give facts upon which to base farm practices that will maintain the crop yields through the years. Sometimes in these field studies, problems arise which make it necessary to resort to the greenhouse and the chemical laboratory for more intense investigation.

IV. *Soil Surveys*: A survey of the soils of the state has been in progress for several years. The soil reconnaissance covers all parts of an area except the mountains and the forests, while the detail surveys are limited to the best lands and more particularly to those that are or may be irrigated. Limited funds have delayed the progress of this work.

These surveys provide an inventory of the soil resources of the state—its most important resource. They are of very great value to all private and public agencies interested in land valuation and in the efficient use of the lands of the state.

V. *Weed Control*: Wherever and whenever possible, weed control should fit into the regular crop production practices of the farm. Tests have shown that 3 to 5 years of alfalfa with grain and some cultivated crop in a rotation will hold most weeds in control. On the other hand, continuous cropping to cereal grains such as wheat, oats, barley, etc., will surely turn the fields finally over to a crop of weeds. Good farming practice is the cheapest and best method of weed control.

WORK WITH GRAIN AND SEED **THE MONTANA GRAIN INSPECTION LABORATORY**

The grain laboratory was established for the two-fold purpose of rendering immediate service and conducting certain research work. The service work has to do with the testing of seed for purity and germination, testing grain for grade and protein con-

tent, and testing wheat and flour for composition and baking properties. The research work is designed to work out certain fundamental problems related to seed testing, the interpretation of the crop producing value of seeds and the milling and baking properties of Montana wheats.

These types of work provide the residents of the state a well balanced service in grain and seed testing, and the grain, seeds and flour received in the routine work of the laboratory often provide valuable material for research work. Also, the personal contact made possible through these tests with farmers, dealers, and millers often presents new problems for research.

Service Work

Seed Testing—The testing of agricultural seeds for purity and germination is of value to both the dealers and the users of the seeds. Many cases come up each year where the owner of the seed tested may avoid considerable loss by being advised of its poor quality. The following are illustrations taken from samples received in 1936:

Red Clover—contained 16.7 per cent weed seeds.

Alfalfa—dark colored—germinated 20 per cent with 10 per cent hard seeds.

Corn—Bright N. W. Dent—germinated 0 per cent.

Wheat—Musty winter—germinated 11 per cent.

Wheat—Light weight bright Ceres—germinated 55 per cent.

Wheat—Bright plump kernalled Ceres—germinated 38 per cent.

Crested Wheatgrass—Bright plump seed—germinated but 59 per cent.

Seed testing is one of the major lines of work of the laboratory. For the year ending June 30, 1936, a total of 2333 samples of seed were received for test, coming from 49 counties in the state.

Seed Inspection—Each spring when the seed stocks are complete, a representative of the laboratory visits the seed dealers of the state and inspects the seeds offered for sale to check on how the analyses of the seed compare with the labels. In 1936, seed offered for sale by 107 dealers located in 30 counties, was inspected. The results of this inspection showed the advisability of buying only tested seed.

Research Work

Some Problems in Seed Testing.—The development of labora-

tory technique for the testing of seeds which will insure uniform results in the various state seed testing laboratories, is a problem which requires careful work and constant checking. In this work, the Montana laboratory maintains a rather close contact with the other laboratories in the United States and Canada through the Association of Official Seed Analysts of North America. An illustration of such special technique grew out of germination tests with crested wheatgrass which presented a problem quite different from slender wheat grass, to which it is closely related. Slender wheat grass is successfully germinated in the laboratory at alternating temperatures of 20° C. for 18 hours and 30° C. for 6 hours. A series of tests made on several lots of crested wheatgrass seed from 2 crop years, indicated that this seed has a rest period, following harvesting, which is similar to that of wheat, oats, and barley. To overcome this rest period, it has been found necessary to germinate this seed at about 15° C. or to prechill it at 8°-10° C. and complete the test at 20°-22° C. A test of this seed on the farm without this temperature control may not give the correct germination of the seed in the fall.

Seed Value of Light Weight Wheat.—Selection was made of 115 lots of hard red spring wheat of the 1935 crop, which ranged from 36.5 to 60.5 pounds per bushel and the kernel weight from 9.0 to 26.5 milligrams. Germination tests were made in the laboratory, the greenhouse, and the field, with results as shown in the following table:

Weight per bushel groups (pounds)	Germination per cent			Yield in bu. per acre
	In laboratory	In greenhouse	In field	
58 and above	87	71	62	14.7
55 to 58	86	72	61	13.8
50 to 55	89	76	59	13.7
45 to 50	88	83	53	10.0
Below 45	79	75	47	8.9

The field tests were made by planting 100 kernels in duplicate rows one rod long and 12 inches apart. The above yields per acre are based on these plantings. The tests indicated that weight per bushel is a good indicator of the crop producing value of seed wheat if the laboratory germination is good.

Milling and Baking Studies with Wheat.—The 1935 crop of

Montana wheat presented some rather unusual milling and baking problems. The wheats were light in weight per bushel but had high protein content. The yield of flour was rather low, in keeping with the weight per bushel, and when the flour was made into bread it proved to be rather low in diastatic activity. This was indicated by the response which was shown when a commercial product known as di-malt, which converts into sugar, was added to the regular baking formula. The result of the addition is shown in figure 3. These studies showed that it is desirable to blend the high protein with lower protein wheats, produced in the more humid regions.



Figure 3. Loaves of bread showing response to di-mant in the experimental baking formula. No. 1, 2, 4, and 5 showed good response, while No. 3 and 6 had poor quality response. Apparently loaves 3 and 6 had poor quality of gluten while the others had good quality of gluten.

RESEARCH STUDIES WITH LIVESTOCK **DEPARTMENT OF ANIMAL HUSBANDRY**

The Animal Husbandry Department studies the relation of type of livestock to management in getting better producing animals, better adapted to Montana conditions. Much study is given to Montana feeds and how to use them in livestock production and fattening.

Studies on Limited vs. Liberal Amount of Feed for Breeding Cattle at North Montana Branch Station

Heifer calves after being weaned in the fall and given a full feed of alfalfa hay during the winter gained 1.06 pounds in live weight per day on a ration of 12.7 pounds hay per day and made a total gain of 142.5 pounds each.

On range pasture the following summer, the heifers fed a limited winter ration gained 62 pounds more than those that had been full fed.

For the next winter as two-year olds, the full fed heifers gained 142.9 pounds each in live weight on 24.5 pounds of alfalfa per day, while the limited fed group gained only 24.9 pounds when fed 9.3 pounds of alfalfa and 5.9 pounds of straw per day.

The heifers fed a limited ration of 7.71 pounds of hay per day made a total gain of 28.9 pounds or 0.22 pound per day. During the following summer on range pasture, the limited fed group each gained about 56 pounds more than the full fed group; yet each weighed 58 pounds less than those in the full fed group at the end of the pasture season.

As yearling heifers, the full fed group gained 174 pounds each or 1.22 pounds per day on a daily winter ration of 21.3 pounds of alfalfa.

The limited fed group required 2.3 pounds of hay and 5.4 pounds of straw to maintain their weight.

On the summer range, the yearling heifers which had been limited fed, each gained 62 pounds more in live weight than those full fed. The latter averaged only 32 pounds heavier than the limited fed group.

During the following winter, the two-year old heifers on a ration of 24.5 pounds alfalfa per day gained 142.9 pounds in live weight, while those fed a limited ration of 9.4 pounds of alfalfa and 5.9 pounds of straw per day gained 24.9 pounds. The full fed heifers thus weighed 150 pounds each more than those limited fed at the end of the winter feeding period. The difference was materially reduced on the end of the next summer grazing season.

On the basis of feed costs with alfalfa hay at \$10 per ton, the record shows that contrasting the full fed groups with those limited fed, the savings per year on the latter group were as follows:

Calves	\$5.14
Yearlings	8.97
Two-year olds	6.70
Total	<u>\$20.81</u>

In other words, the feed cost of growing out a range breeding cow when fed a limited ration during the winter was \$20.80 less than for those fed a full ration on alfalfa hay. While the limited fed

group of cows weighed a little less, there was no difference in the number of calves from them as cows, nor in the birth and weaning weights of their calves.

Comparison of Types of Bulls at the North Montana Branch Station

In the spring of 1936, the 42 calves from large type bulls at birth weighed on the average 10 pounds more than the average for 60 calves from the small type. When weaned, the large type calves weighed 441.8 pounds each, and the small type 372 pounds—a difference of 69 pounds.

The heifer calves from this breeding were wintered over on alfalfa hay. The small type heifers gained 0.95 pounds per day and ate 12.51 pounds of hay for one pound of gain, while the large type heifers gained 7.17 pounds per day and ate but 11.44 pounds hay per pound of gain.

During the summer of 152 days on mountain range, the small type heifers gained 230 pounds and the large type 260 pounds each, or 30 pounds more.

As yearling heifers on winter feed, the small type gained 1.24 pounds per day and required 17.26 pounds of alfalfa for one pound of gain. The large type heifers gained 1.21 pounds per day and ate 17.58 pounds of alfalfa for each pound of gain.

As two-year old heifers, the small type group, during the pasture season, gained 210 pounds each and the large type group gained 243 pounds. In the following winter feeding period, the small type heifer gained 87 pounds, while the large type gained 80 pounds.

The weight of these heifers when added to the breeding herd in the spring was 460 pounds each for the small type and 527 pounds for the large type.

The steer calves from this breeding tell a similar story. Those from the small type bulls fed on alfalfa hay for the winter, after weaning, gained 128 pounds each as compared to 160 pounds for the large type; but the small type ate .43 pounds more hay for each pound of gain.

When grazed for the summer, the small type steer gained 257 pounds each and the large type 276 pounds.

These steers as yearlings were shipped off grass to Chicago. The small type steers sold for \$8 per hundredweight, as they were a more desirable type, while the large type steers sold for \$7.25 per

hundredweight. However, the small type steers weighed only 698 pounds compared to 812 pounds for the large type.

Grazing Sheep on the Range Throughout the Year

Summer Range.—Nine hundred and three ewes and 1108 lambs were grazed on the Gallatin National Forest from July 1 to September 5, 1936, a period of 66 days. This tract contains approximately 4040 acres. The twice over system of grazing was used. It was not a satisfactory grazing season because of the many weeds and the dry weather. No rain fell from the time the sheep entered the forest until about two weeks before leaving it—too late for the range to recover.

The ewes averaged 116.0 pounds when taken to this range and 134.3 pounds when removed, thus making a gain of 18.3 pounds or 0.27 pound average daily gain.

The lambs averaged 47.0 pounds when going on the range and 72.2 pounds when removed, a gain of 25.2 pounds or 0.38 pound average daily gain. Two hundred and thirty-seven of the lambs were fat enough to ship and were sent to Chicago immediately after weighing off the range. Eighty-four and four-tenths per cent of this load of lambs was Hampshire-Rambouillet cross-breds. They weighed 86.5 pounds on the Chicago market and sold for \$9.35 per hundredweight.

Winter Range.—The station flock of 1031 ewes was wintered on the range in 1935-36. Some of them received no supplemental feed and others a limited amount. The ewes on pasture alone lost 5.3 pounds per head during the 90 days on the range while those receiving a limited amount of grain concentrates made a slight gain. There was no measurable difference between the groups in the lamb and wool production.

Two hundred and thirty-two lambs were also wintered on a similar range as were the ewes. One group of lambs fed on range grasses only lost 7.4 pounds per head during 90 days. The other lambs received a limited amount of concentrates and gained about 2 pounds each during the winter. The most noticeable difference was that the lambs getting the supplements each produced three-fourths pound of wool more than those on pasture alone.

DISEASES OF THE FARM CROP

DEPARTMENT OF BOTANY AND BACTERIOLOGY

This department is studying many of the troubles and diseases

of the farm crop, whether they originate in the soil or in the plant itself. During the past year, much of the time of the men of the department has been given in an attempt to solve certain major diseases of the sugar beet, a very important crop in the lower valleys of the state. The beet is a valuable cash crop and also a great help in keeping the land free of weeds, and the soil in good tilth.

In field tests that have been carried on for 24 years at the Huntley Branch Station, crop rotations were set up which included 2 and 3 years of alfalfa, 1 year of sugar beets and 1 or 2 other kinds of crops. In the past 5 to 10 years the yield of sugar beets in the rotation has been reduced 75 per cent, while the yield of other crops in the rotation has been well maintained. This department has been studying the causes of this reduction in beet yields and is working to devise methods of restoring them.

Another important cause of the trouble appears to be certain root diseases which attack the roots of the seedling beets and reduce by 70 per cent the theoretical good stand. The disease, or group of diseases, which is causing the trouble is being thoroughly studied.

There are also indications that in certain parts of this experimental area there may be a lack of some essential plant food, particularly phosphorus. This problem is also receiving further study.

INFERTILE SOILS AND MEANS OF IMPROVEMENT

DEPARTMENT OF CHEMISTRY

A major activity of this department is the study of infertile soils found in various parts of the state, their cause, and how to overcome the difficulties. Extensive studies have been carried on to test the value of various forms of phosphorus to correct these deficiencies, especially in the irrigated areas. Very valuable results have been obtained. The first problem is to locate deficient areas. This is a long drawn-out task because Montana is a large state and the deficient areas are widely scattered. An encouraging feature growing out of the observations made in connection with this study is that the farmer who systematically uses barnyard manure on his crop is postponing for many years the need of continuous application of phosphorus.

The effect of using different kinds of phosphorus is shown very markedly in figures 4 and 5. On the farm where these crop

samples were obtained it is clearly very important to use the right kind, viz. for Montana treble superphosphate and the super phosphate. The character of the soil may make some difference in what is needed and this problem is receiving further study.

It is sometimes very difficult to find out why a soil fails to grow a crop. Complaints about soil troubles from the western part of the state indicated the need for a special investigation. On a visit to the area, a thorough examination was made of the soil. Samples of soil were then taken to the laboratories at Bozeman where chemical and other analyses were made. With this in-



Figure 4. Effect of different phosphates on grains. 1. Treble superphosphate. 2. Superphosphate. 3. Mono calcium phosphate. 4. Check. 5. Calcium meta phosphate. 6. Di-calcium phosphate. 7. Fused phosphate rock.

formation, it was decided to study the response of spring wheat when planted on the original soil and after adding various fertilizers. Four jars were filled with the soil; one jar received no treatment but to the others definite amounts of lime were added. In addition, phosphorus was added to jar 3 and phosphorus and potash to jar 4. The wheat in these 4 jars, after the above treat-



Figure 5. Effect of different phosphates on alfalfa. 1. Check. 2. Fused phosphate rock. 3. Calcium meta phosphate. 4. Mono calcium phosphate. 5. Di-calcium phosphate. 6. Superphosphate. 7. Treble superphosphate. 8. Check.



Figure 6. An experiment to determine the effect of lime phosphorus and potassium on the rate of growth of spring wheat.



Figure 7. In this experiment the same soil was used as in figure 6 except ground alfalfa leaves were added to all jars. hPoto-graph taken 42 days after planting.



Figure 8. Same as Figure 7. Photograph taken 72 days after planting.

ments, showed very poor germination and very small growth in all, with the best growth, however, in the jars treated with phosphorus, as shown in figure 6.

The soil was next removed from all the jars and an equal amount of ground alfalfa was added to all the soil and thoroughly mixed. Spring wheat was again planted and the results are

shown in figure 7, a photograph taken 42 days after planting. The same jars one month later are shown in figure 8.

The chemical and other tests showed that this soil contained a large proportion of magnesium, so lime was added to improve the lime-magnesium ratio. The test in the jars showed that phosphorus and potash were needed, and adding ground alfalfa demonstrated the need for vegetable matter or humus. This soil would therefore be very much improved by treating with lime and by a heavy coating of partly decomposed barnyard manure supplemented by superphosphate and perhaps some potash.

ANTICIPATING AND CONTROLLING INSECT OUTBREAKS **DEPARTMENT OF ENTOMOLOGY**

One of the greatest aids to successful farming in the state is the forewarning of threatening insect outbreaks. To achieve its purpose the prediction of widespread insect scourges must be made far enough in advance to allow for financing, purchase, and transportation of needed poisons and other materials, a certain amount of educational work as to methods of control to be employed, and, in some cases, in time to put into practice cultural methods designed to obviate the expected crop injury. The prediction of any coming event is hazardous to be sure; only in the exact sciences can it be done with any great accuracy. As one digresses from mathematics, astronomy, physics, etc., where great precision in prediction is possible, into biology, sociology and economics, where knowledge of controlling conditions is far less exact, the hazards of prediction are proportionally increased. Therefore it is to be expected that some mistakes will be made as to the time, severity, and exact location of insect outbreaks, but the experience of the last four years has shown rather conclusively that great savings to crops can be effected through advance knowledge that trouble from certain destructive insects is imminent.

The basis of this biological prediction has been made possible through the thorough study of the life habits of our important insect pests and by the increase in knowledge concerning the environmental influences upon them. The dependability of these predictions and their extension to an increasing number of insect pests calls for continuing this thorough study. The effectiveness of these predictions depends on the annual insect survey.

The grasshopper surveys are now made cooperatively by the United States Department of Agriculture, the Montana Agricultural Experiment Station, the Agricultural Extension Service, and the Office of the State Entomologist. The work on the pale western cutworm, the beet webworm, codling moth, etc., are made by the Experiment Station. Predicting probable outbreaks of these latter groups of insects is yet in more or less the formative stage. Particularly is this true of the beet webworm with its complicated life history, its ability to carry over to the succeeding year either from its first or second generation, or from both, the very important nutritional factors controlling the production of eggs by the moths, and many other factors now under investigation.

New Methods of Insect Control and Making Their Use Effective

The prediction of insect outbreaks is in itself no aid to the farmer unless he has effective means and methods of preventing the expected crop injury. Consequently the entomologist must develop greatly improved ways of insect destruction to make this program complete. Leaning toward such advancements are projects dealing with insecticides, the physiology and environmental responses of important insect species, and the complete and detailed studies of their life histories, which are now under way. The use of an insecticide may, however, be very ineffective when used under unfavorable temperature or other adverse atmospheric conditions. Years ago this station in studying the feeding habits of grasshoppers found that they did not feed until the morning temperature got up to about 70°, and that in general they stopped feeding when the temperature reached 85° to 90° F. This had a very important bearing on the proper and most effective use of poisoned bran mash. For the best results the bait must be applied when the grasshoppers are hungry for some moist material. No other single discovery about grasshopper control ranks with this rather simple finding. Work of a similar kind on the use of insecticides for other kinds of insects we find is also proving fruitful. The application of poison dust to Mormon crickets kills them most promptly when the temperature is high. Whereas the crickets may require several days at 70° F. to succumb to the poison, they are killed in a very few hours at 90° F. Furthermore it seems most important to get the poison on the tarsal (foot) pads. They die just as promptly from a minute quantity of soluble arsenic on their

feet as when the whole body is dusted with the poison. This has important bearing on the use of dust barriers in controlling the great bands of these destructive insects.

Insect Characteristics an Aid to Their Better Control

Different species of insects have peculiar habits and characteristics on which specific control measures can be most advantageously based. To find these points for vulnerable attack requires careful study of all stages of the insect and under varying conditions of temperature, humidity, light, and other controlling factors. Unfortunately, at times an effective means of control is devised which is out of line with recommended general cultural practice in a given locality. This is the situation with Say's grain bug. It occurs and has caused immense damage in an area where soil blowing is also an important problem. The preparation of fields to control blowing promotes the successful overwintering of the grain bugs. The weak spot in the insect's life is during the early spring when they are still in hibernation under the weeds or little clumps of straw left by combines, or other sources of protection. Burning this cover early in the spring is a very effective method of destroying this insect but such a practice increases possibilities of soil blowing. If Say's grain bug continues to be as serious in north central Montana as it has been during the last five years, here is a problem for further study which will have to harmonize insect control with the best farm cultural practice for control of soil blowing.

During the past few years with the State suffering from some of the worst insect outbreaks in its history, the fund of information on control methods developed by the Experiment Station has served to alleviate to a very important extent the financial losses which otherwise would have resulted.

PLANT RESPONSE TO FERTILIZERS DEPARTMENT OF HORTICULTURE

The Department of Horticulture conducts studies with bush and tree, fruits, potatoes, vegetables of all kinds adapted to the various parts of the state, and with trees and shrubs whether planted as windbreaks or as ornamental surroundings for the farmstead. Studies are also made with flowers.

The activity of this department, while centering in Bozeman,

extends over the state, for there is work being carried on at all the Branch Stations and in many other places where cooperative studies have been undertaken with many of the farmers and others especially interested in the problems this department is endeavoring to answer.

Because of deficiencies in certain soils in various parts of the state, the department has been giving special study to the value of particular fertilizers and combinations of these in obtaining not alone maximum yields but also higher quality of product. Some of these problems are presented in the following report on the work of the department.

Influences of Nitrogen and Phosphorus on Apples

The value of nitrogen as a fertilizer is determined in part by the availability of phosphorus in the soil. Nine years work with commercial fertilizers in orchards in western Montana has led to this conclusion. The soils of Montana orchards are almost universally deficient in available phosphorus. With continued cropping, nitrogen has also become deficient. As a result, in this state, two deficiency elements rather than one have to be studied.

In the experimental orchards, nitrogen, whether applied alone or in various combinations, responds almost directly with the availability of the phosphate present in the soil. The color of the fruit has been checked very carefully for each plot to determine the percentage of the red area. Using this color as a measure, it was found that the average color reading on the fruits from the nitrogen plot has been 64.34 per cent with some variance above or below this in different years.

When the same amounts of nitrogen have been applied with phosphorus, an average color reading through the nine-year period has been 81.13 per cent. Check plots which have received neither nitrogen nor phosphorus give an average color of 83.19 per cent, which was about the same as on an adjoining plot where phosphorus only was applied. This would indicate that the effect of nitrogen as far as color is concerned is in turn influenced by the presence or absence of phosphorus. The influence of nitrogen upon the firmness of the fruit also varies when used with or without phosphorus. On January 1, the pressure record on fruit gave a reading of 9.4 pounds for the fruit from the nitrogen plot as contrasted with a reading of 10.7 pounds pressure from a nitrogen-

phosphorus plot. The test of apples from a check plot on the same date gave a pressure of 10.97 pounds. The spread in the pressure increases towards the end of the storage season.

The plots to which phosphorus was added and the application continued did not drop in color with the addition of nitrogen. Plots to which nitrogen had been applied immediately improved in color when the nitrogen was eliminated from the spring fertilizer program. These results indicate one kind of response from nitrogen fertilizers if such an element as phosphorus is also deficient and a still different response when this deficiency of phosphorus is corrected. Perhaps the same rules would apply to other combinations of fertilizer.

Effect on Crops from Amounts of Fertilizer Applied

Benefits from the use of phosphorus have not increased in proportion to increases in applications. Variations were made in 1936 in the amounts of phosphorus as applied to different plots, starting in with an application at the rate of eighty pounds of treble superphosphate per acre to one plot and increasing it by degrees in other plots until an application of four hundred pounds per acre was applied.

The plots with the heavier applications did not give as favorable responses as did those with the lighter applications. The heavy set of tubers per acre occurred with the lighter applications, and the yields were directly in proportion to tuber set. When an application of two hundred pounds per acre had been reached, the maximum benefits were also reached on these particular plots, though even with this application, the results were only slightly above the lighter applications. Beyond two hundred pounds per acre, the set gradually decreased and the total yields were also lower. This experience may not apply to all parts of the state.

Responses of Transplants to Fertilizers

Studies on the effects of fertilizers and chemicals on vegetable transplants indicate a significant relationship between various methods of transplant handling and crop performance. Quantitative and qualitative changes in transplant growth, as affected by modified transplant environment, materially affected the later development of the crops produced. Potassium permanganate and dextrose when applied in small quantities alone or in combination

with other fertilizer materials, particularly phosphorus and nitrogen, had appreciable stimulating effects on the growth of transplants, but particularly on root development, giving a compact, fibrous root system. Potassium permanganate greatly hastened maturity with most of the crops studied, even when used in combination with nitrogen which, used alone, distinctly delayed maturity. Potassium permanganate and nitrogen in combination increased the yield of early tomatoes by 60 per cent to 37 per cent over the checks. Potassium permanganate is an effective oxidizing agent and probably has the indirect effect of releasing certain elements from the soil which otherwise would be unavailable to plant growth. Dextrose was found to greatly stimulate biological activity in the soil which may, in turn, have altered its nutritional condition.

Factors Influencing Storage and Handling Qualities of Potatoes

Handling and storage qualities of potatoes have been improved by the proper use of fertilizer. In tests on seventy-six plots of potatoes made in various parts of the state, every one showed evidence of phosphorus deficiency. The use of fertilizer, particularly the use of phosphorus, has materially improved the handling qualities of potatoes produced in these tests.

From the 1936 crop, studies were made with the Bliss Triumph variety on the percentage of potatoes that were cracked and damaged incidental to handling. Of the potatoes which had received no treatment, only 35 per cent of the tubers were sound and not damaged in any way; while from the phosphated plots, about 72 per cent were free from any skin breaks. The use of phosphorus has apparently developed a tougher surface as well as better maturity, and made the potato less subject to mechanical damage.

Storage conditions are naturally influenced by mechanical damage while dry rot is always a factor accompanying bruising and other forms of mechanical damage. Such damage alone in the test plots in 1936 would warrant the use of phosphorus.

SERVICE FOR THE RURAL HOMEMAKER

DEPARTMENT OF HOME ECONOMICS

The Home Economics Department aims to carry on research that will directly serve the rural homemaker by furnishing information that answers some of her immediate problems in the

preparation and preservation of food, the selection and care of textile fabrics, and in home management. It is believed, however, that the department can ultimately perform a yet better service by investigating some of the fundamental conditions that lie back of these problems.

For instance, to fully understand the value of foods we must know all the factors which affect their value. We have been gradually learning how much of protein, fat, carbohydrate, and also of minerals and vitamins, are needed by each person per day in order to maintain a condition of good health. This laboratory has given special attention to determining the vitamin and mineral content of many of the common foods used in Montana, such as potatoes, carrots, cabbage, sweet corn, peas, etc., to see what the processes of preparation and preservation may have on their essential qualities. Plans for future work include a continuance of this study, until it may be possible for Montana homemakers to more accurately judge the full nutritional value of the family's food.

There are many requests from consumers for information about the selection and care of the textile fabrics used in the rural home. These can only be answered accurately after carrying on considerable detailed research involving the nature of the textile fiber and its quality, the construction of the fabric, the thread count, yarn size, strength, wearing quality, and the results of various methods of cleaning, pressing, etc., which include the effect of water, acids, alkali soaps, substitutes, cleaning fluids, light, cold, and heat on the fabric. Such a study has been undertaken by this department, using a silk fabric (silk hose) as the textile material. It is planned to continue such studies until other fabrics used in the home shall have been studied in a similar way.

Home management, which includes the making of budgets, the development of better methods of operating the household, and the assembling of information about the selection and care of household equipment and furnishings, deserves much careful research from the economic and scientific standpoints. A few preliminary investigations in this field have been started by securing data concerning the income and expenditures of a number of farm homes in Montana, and by determining the method of operating a steam pressure cooker at altitudes much above sea level, thus insuring safe products in canning. With a limited working force

progress in such studies will of necessity take several years to be fully worked out.

SOURCES OF IRRIGATION WATER **IRRIGATION AND DRAINAGE DEPARTMENT**

The vast areas of fertile land in Montana can be developed and made productive only through the conservation and use of the limited but still undeveloped water resources. This development will be accomplished through the diversion of rivers and streams and the storage of flood waters for irrigation. The dependence of agricultural security in Montana upon such irrigation development is now fully recognized. However, before constructing dams, canals, and ditches, it is most important that the average amount of water that may be made available for irrigation in various parts of the state be known, both for direct diversion and for storage. It is important also to know the actual amount of water available during each season of the year. The snow surveys now being made on the high watersheds add to this knowledge, for the water content of the winter's snow is an index to the amount of runoff from the watershed during the following summer. Snow measurements on April 1 and May 1 indicate how much water will be available for irrigation so that the farmer and canal manager can plan accordingly.

In many parts of the state, water for irrigation may be obtained by pumping from shallow wells, barrow pits, and from streams which are too deeply entrenched for economical diversion by gravity. These small projects can best be developed when low cost pumping equipment is available. To meet this need a home-made centrifugal pump was developed by the Agricultural Engineering Department of the Station. It is described in Bulletin 324 and in Circular 150 of the Experiment Station.

Intermittent streams which drain large areas in the eastern and central parts of the state do not provide a dependable flow for irrigation projects; nevertheless, they can be made useful by the practice of flood irrigation. This system, which has proved successful in the production of hay and grain, is now being investigated for its possibilities as a means of improving the grass crop on range land.

Many other problems of diverting the runoff from all kinds of land are being studied so that the water may be more widely

spread over limited areas and held there until it has percolated into the soil, thus aiding in the increased growth of crops.

INVESTIGATIONS OF ANIMAL DISEASE VETERINARY AND RESEARCH LABORATORIES

The work of the Veterinary Research Laboratory is devoted almost exclusively to experimental studies, and investigation of animal disease problems arising in the field and not handled by the State Livestock Sanitary Board. Certain phases of several projects have progressed to a point of making possible the report of results.

Coccidiosis in Cattle

During the past year some new facts on coccidiosis in cattle have been obtained. The examinations of normal, healthy cattle have been negative for the presence of coccidia except in a few isolated instances. When coccidiosis occurs, it is usually very difficult to account for the source of infection, if it is assumed, as has been the practice, that coccidia are present in cattle, only at the time when clinical coccidiosis appears. By a modification of the technique of fecal examination, however, coccidia has been found present in nearly all healthy cattle examined, but in numbers so low that they have been overlooked when examined by the usual methods. The conclusion that coccidia are normally present in healthy cattle makes possible the explanation of winter outbreaks of coccidiosis, without looking for other sources of infection. Our study indicates that clinical coccidiosis is the result of the lowering of the resistance of the cattle by environmental conditions, and the consequent extension invasion of the coccidia. This gives a basis for preventive measures, which would consist of keeping up to normal the natural resistance of the host, especially the calves, by avoiding sudden changes of feed, as from range to alfalfa hay, by supplying adequate watering and salting facilities, by using natural range as much as possible, and starting calves on supplementary feed early in the winter.

Dysentery of New-born Lambs

Extensive observations through seven years on dysentery in new-born lambs shows this to be largely a disease of early lambs when shed lambing is practiced. During six lambing seasons, about 150 lambs from some 125 ewes have been maintained at the labora-

tory for use in these studies. The results are now ready for publication.

As a result of these studies it has been concluded that dysentery of new-born lambs in Montana is a resultant of several factors, rather than a specific infectious disease caused by a specific pathogenic organism. Among those factors are low temperatures with snow or rain, unsanitary conditions of the lambing sheds and corrals, and the presence in the environment of strains of ordinary intestinal bacteria which have increased pathogenic power. These factors result in lowering the vitality, or resistance of the lamb, to which may be added the ingestion during the first day of life of a relatively large number of bacteria from filth. The bacteria involved are the usual species found in the intestinal tracts of normal lambs, usually *Escherichia communior* or closely related species, and more rarely, *Clostridium welchii*.

Attempts to control this disease by the use of anti-serums have not been satisfactory, although not without some effect. Treatment of affected lambs with intestinal antiseptics when given early has been of some value. Losses have also been definitely reduced by the administration of intestinal antiseptics to all lambs born during a severe outbreak.

Fundamentally, the problem of the prevention of dysentery of new-born lambs is a sanitation problem, resulting from the conditions produced by lambing in sheds and yards or occurring two or three months earlier than the natural lambing season.

Black Disease in Sheep

Work has been in progress for several years on a study of this disease, with the object of developing an immunizing agent. It causes a considerable death loss in farm flocks of sheep in areas where liver fluke is prevalent, and is due to infection with *Clostridium edematiens*. During the past year we have developed an alum-precipitated toxoid which is highly effective in preventing the disease in laboratory experiments. A field experiment is now in progress to test its efficiency under field conditions.

"Lunger Disease" in Sheep

A chemical study of the lungs of "lunger" sheep as compared with normal lungs at various ages has been completed. Determinations of silica, iron, aluminum, calcium, magnesium, and phos-

phorus pentoxide were made. The dry weight of "lunger" lungs was more than double that of normal lungs. The percentage of ash of the "lunger" lungs was 1.27 times that of normal lungs. The average percentage of all the minerals determined was somewhat greater in the "lungers" than in normal sheep. The percentage of silica in "lunger" lungs was nearly double that in normal lungs. The significance of this difference has not yet been determined.

Necrobacillosis

Studies on necrobacillosis show that a small percentage of soil cultures of *A. necrophorus* remained viable for three years, but no evidence was obtained of reproduction in soil cultures. These results seem to indicate that *A. necrophorus* does not live in the soil as a saprophyte, but that the organisms may remain alive in soil for extended periods under favorable conditions and be capable of reproduction when transferred to suitable media.

THE WEATHER FOR 1936

The year 1936 was noted for extreme climatic changes. The temperature was quite erratic. Starting on January 25 and continuing until February 20 there were 24 days the thermometer ranged from zero to 43 degrees below—the coldest temperature recorded at this station. The mean temperature recorded for this period of 25 consecutive days was -4.5 degrees. This again is the coldest record for 26 consecutive days. On March 30 the temperature dropped to 14 degrees below zero and the cold wave extended into April. On All Fool's Day the thermometer registered -10 degrees, the lowest ever recorded for April at Bozeman. The nearest approach was in 1896 when the thermometer dropped to zero on the 16th and again in 1906 when -1 degree was recorded on the first. The mean temperature for April 1936 was above normal, however.

In six months of the year 1936 sub-zero temperatures were recorded. This has been equalled only once in the past 37 years, and that was in 1919. This is some contrast with the years 1925 and 1926 when no sub-zero weather was recorded between April 1925 and December, 1926, and only twice during that period did the thermometer drop to zero.

During the spring the temperature rose to above normal. Notwithstanding the fact that April had the coldest temperature ever

recorded, the mean for the month was 1.9 above normal. The mean temperature for the months of June, July, and August, taken collectively, was 64.2 degrees. The nearest approach to this was in 1934 when the mean temperature for the same months was 63.0 degrees. The mean temperature for July 1936 was 72.0 degrees, the highest ever recorded for that month. These high temperatures accompanied by winds above normal and relative humidity below normal, brought about a rapid evaporation of water from the soil and, hence, lessened the value of precipitation and irrigation water. The total evaporation for April to October, inclusive, was 48.778 inches. This is 9.207 inches above normal.

The annual precipitation was 12.78 inches. This is the lowest ever recorded with the exception of 1919 and 1934 when the annual precipitation was 11.28 and 10.54 inches, respectively. The precipitation that fell during the growing season was also higher than for 1919 and 1934, but the higher temperatures and greater wind

WEATHER SUMMARY FOR 1936

1. Highest temperature	96	July 22
2. Lowest temperature	—43	February 8
3. Greatest range for year	139	
4. Highest monthly mean	72.0	July
5. Lowest monthly mean	5.2	February
6. Highest daily mean	80.5	July 22
7. Lowest daily mean	—26.5	February 7 & 13
8. Mean temperature for year.....	42.9	
9. Greatest total precipitation for 1 month	2.13	June
10. Least total precipitation for 1 month..	0.09	July
11. Total rainfall	12.78	
12. First killing frost.....		September 15
13. Last killing frost		May 21
14. Number of clear days in year.....	101	
15.....Number of partly cloudy days in year	204	
16. Number of cloudy days in year.....	61	
17. Days with 0.01 inch or more precipitation	93	
18. Total evaporation from April to Octo- ber, inclusive	48.778*	

*Evaporation records for April not complete.

velocity decreased the value of precipitation until the drouth was felt as keenly as in 1919 and 1934, the two driest seasons experienced up to those dates.

THE AGRICULTURAL BRANCH EXPERIMENT STATIONS

There are five branch Experiment Stations, three owned by the state and two by the Federal Department of Agriculture. They have been located in different parts of the state so that a study could be made of these local areas. They have different elevations, different climatic conditions as related to rainfall, temperature, to the length of the growing season; and they have also different agricultural possibilities and needs under range, dry farming, and irrigation agriculture. The continued and enlarged support for the work at these Branch Stations is imperative if the Stations are to serve adequately the various areas.

THE HORTICULTURAL BRANCH STATION

This station, located in the Bitterroot Valley by the legislature of 1907, was established to study especially the fruit problems of this valley and of the whole western part of the state. It is a local center for the studies carried on with the fruit problems of the state by the station departments of Horticulture, Entomology, and of Botany and Bacteriology in their special fields. The results are reported from the Bozeman headquarters.

Cover Crops in Orchards

For many years clean cultivation was practiced in the orchards of the Bitterroot Valley, but questions finally arose as to the desirability of continuing this practice. Thus studies were undertaken with cover crops in the station orchards. This brought up yet another question as to the best way to start these crops in the orchards. Studies showed that a fertilizer program was desirable when establishing such cover crops if good and vigorous growth of trees was to be expected. Without such fertilization the leaves are very small and light in color. The fruit also will be small and light in color.

When nitrogen fertilizer was used, growth was well maintained with good size of fruit. The leaves were large and of a healthy green. The fruit, however, had an average color reading of less than 60 per cent. When nitrogen and phosphorus were used, all the benefits that had been obtained with the use of nitrogen

were also evident, but the phosphorus added distinctly to the value of the fruit due to a gain of thirteen points in color.

The establishment of cover crops draws so heavily on the soil fertility the first year that fertilizer applications which include phosphorus as well as the nitrogen appear to be desirable.

THE JUDITH BASIN BRANCH STATION

This station, located in Judith Basin County, serves the central part of the state. The area of land used is about 600 acres, and the farm buildings are about two miles from Moccasin. This is the oldest Branch Experiment Station in the state, having been authorized by the state legislature of 1907. Studies on cropping methods, on cereal production and varieties, and on forage crops adapted to the dry lands of this area have been in progress since the beginning of the station work. Early in its history so that a study could be made of varieties of trees that might be adapted to this area, deciduous and evergreen trees were planted, and these plantings have been added to as the years have passed. Later still livestock were secured, primarily to test the value of forage and pasture produced at the station, but also to study production costs under various methods of management.

Study of crop rotations best suited for the dry farm were among the first to be started, and these have demonstrated the value of the alternate cropping and fallow method for grain growing. Corn has proved valuable as a fallow crop when introduced occasionally in the rotation. It also provides very good winter forage.

At this station many varieties of spring and winter wheat, oats, barley, etc., have demonstrated their worth under Montana dry farming conditions and are now grown all over the state. The hardiness and productiveness of many kinds of forage crops have also been tested, such as corn, sweet clover, Ladak alfalfa, brome grass, crested wheat grass, etc.

The pasture tests carried on for 12 years have shown the very valuable qualities of brome grass and crested wheat grass. During the past few dry years the latter grass has fully demonstrated its great value as a pasture for this northern area of the country. Studies with this grass are being extended to learn how to get better results through improved methods of seeding and management and the finding or development of improved varieties.

The observations made on the trees and shrubs planted over 25 years ago indicate several varieties that grow and thrive on the benches of the Basin, providing considerable shelter to the buildings and adding very much to the appearance of the station. While the experiences indicate that trees may have a somewhat limited existence on these dry lands, yet continued planting through the years has maintained the groves and the windbreaks. In spite of the adverse conditions it is possible to have trees and shrubs on the dry farm.

A lot of valuable information, accumulated from the studies carried on since the station started, should be more fully studied, analyzed and written up for publication. The limited funds provided during the past few years have not permitted as broad or as thorough a study of this material as is necessary and desirable.

For three or four years this station has experienced the most adverse weather conditions since it was established. But little over one half of the average yearly rainfall of the previous 25 years has fallen, while hot weather and high winds have added to the cropping difficulties. It has been a severe test of the cropping plans of the station but out of it is coming added knowledge, and to increase knowledge is the foundation purpose of the station.

THE NORTH MONTANA BRANCH STATION **Climatic Conditions**

Climatic conditions in 1936 were the most unfavorable in station experience, the annual precipitation being 7.67 inches as compared with a 20 year average of 11.66 inches. Seasonal rainfall during the important months of May through August was only 3.60 inches or approximately one-half normal. The year was characterized by wide extremes of temperature, with an absolute range from 105 degrees above to 48 degrees below zero. Oddly enough, both the coldest and warmest months on record occurred, February having a mean temperature of -14 degrees and July a mean of 80 degrees.

There was no opportunity for moisture storage, the subsoil being dry from early summer until the end of the year. However, sufficient precipitation occurred near the time of planting to insure uniform stands of most crops, but later conditions of drouth and high temperatures resulted in the worst failures ever witnessed here. Usually some crop, variety, date of planting, tillage method,

or isolated plat, produces relatively well even in the driest seasons; but in 1936 failures were complete and all-inclusive.

General Statement

During the past two decades the North Montana Branch Station has been investigating certain practical problems in the field of crop production and livestock feeding, which information has been of general value to tillers of the soil engaged in developing a new farming country, and to stockmen faced with problems in using feeds other than those on the range. As a whole the fundamental principals of crop production and the efficiency of various locally grown forages and feed grains have been indicated by these experiments.

During the course of investigational work it was found in many instances that agricultural practices borrowed from older regions did not fit the conditions here. Thus it was discovered that fall plowing, the dust mulch, and orthodox crop rotation systems were not well adapted for practical dry land farming. In a similar manner it was learned that certain locally grown livestock feeds had important values as compared with results based on experience in other sections of the country. One need only to mention the successful fattening of hogs on rye and the fact that small grain hays, especially oat hay, possess here a feeding value equal to alfalfa for wintering beef cattle.

These facts show that agricultural research must be rather cautious in the transfer of assumptions from one region to another. However, this point of view must not be carried to an extreme because in many instances conclusions already drawn can be applied, thus avoiding a duplication of effort, commonly observed in the planning of agricultural research for a relatively new region.

The contributions of the North Montana Branch Station in the field of research may be summarized under two general headings: first, that type of investigation which has had to do with establishing certain fundamentals incident to the region, including such items as tillage method and crop rotation projects, date and rate of seeding experiments, variety tests of well known crops, and comparative values of local feeds and forages when utilized by different classes of livestock; second, the contributions to agricultural knowledge which grow out of the experience and ramifications of the routine research mentioned above.

Studies in Agronomy

Tillage and crop rotation studies, forage investigations, and crop breeding were the major activities in experimental agronomy during 1936. Seed bed preparation has had an important influence upon the success of crop production, second only to the influence of seasonal weather. However, in 1936 all methods and practices of handling small grains were complete failures from a practical viewpoint. One significant observation however, was the fact that crested wheatgrass, sown in the fall of 1935 in weedy abandoned farm land, very successfully survived the ravages of drouth, heat, and insect pests.

Agronomic investigations in recent years have also contributed certain additional ideas regarding dry land agriculture, a few being mentioned in the following paragraphs.

Plowless Fallow.—The practice of plowless fallow has found widespread application in dry farming areas. Station results suggest, however, that this method of land preparation should not be carried to an extreme since the average yield of Marquis wheat on May-plowed fallow for 10 crop years, from 1926 to 1936, was 18.2 bushels per acre, whereas plowless fallow produced 15.3 bushels. From the standpoint of expense in relation to the acreage covered at the proper time and to the relative yields obtained, plowless fallow has certain points of advantage. On the other hand there is some evidence in many localities that plowless fallow tends to blow more readily than plowed fallow, the differences in soil type, the frequency and depth of cultivation, the kind of implement used, and the amount of soil moisture at the time of working being other factors modifying the problem.

Crop Rotations.—The matter of crop rotations for dry land needs some clarification since many of the popular ideas of rotating crops do not work well here. Thus the use of green manures in a regular rotation system on dry land fails to give the results usually realized in the more humid sections. There has been no benefit to the crop planted immediately after the green manure, nor have other crops in the same rotation responded.

This also has been true with respect to grass and alfalfa carried in a regular rotation of small grains and corn. In many cases the yield of the crop immediately following has been less and the production of other crops in the same rotation unimproved. The

idea of a deferred system in which permanent grasses or legumes are allowed to remain for a number of years before being brought into a cultivated rotation is receiving consideration as a means of adapting satisfactory crop rotations for these conditions.

Continuous Corn.—Field investigations have shown that continuous corn has a marked advantage in productivity of fodder and shelled corn as compared with corn grown on plowed stubble after small grains. The favorable yield reaction to continuous cropping with many intertilled crops is an interesting feature of the work at this station.

Forages.—The reclamation of abandoned land by the use of fall sown crested wheatgrass is an important contribution. The fact that no cultivation is needed and that the grass can be successfully established by sowing at a thin rate with an ordinary grain drill directly in the stubble or weeds, indicates an economical method of regressing areas in relatively few years, which otherwise would require perhaps several decades.

Cereals.—Breeding work with wheat, oats, and barley, has shown that better strains than those now commercially grown can be expected in the future from results of hybridization and selection. A variety of spring wheat, Comet by name, developed at this station has capacity to yield under drouthy conditions. Whereas, this wheat is not recommended for milling purposes, it is being used extensively in crossing, out of which segregates of better quality and yield are hoped for.

The yield of hybrid corn from crosses between locally developed inbred strains has indicated that adapted crossed seed corn may have an important place in this section of Montana. Under conditions where yields are relatively small, the increased productivity of crossed corn is often quite pronounced.

Seasonal Weather and Small Grain Yields.—Relationships between various climatic factors and the annual yields of grains and forages have been studied somewhat extensively. These investigations have shown that numerous rainfall and temperature reactions are involved, all of which have an important influence upon crops grown for seed or forage. Early season moisture has much to do with the yield of wheat, oats, and barley. Many of the factors predisposing good or poor yields occur previous to the time of heading. With reference to forage production, good distribution

of rainfall and equable temperatures seem necessary if maximum yields are to be anticipated.

Horticultural Studies

Shelter Belts.—Species best adapted for shelter belts are the American Elm, Western Yellow Pine, Caragana, and Scotch Pine. The choice of trees for shelter belts is between fast growing short lived trees which might attain fair size, or slower growing species which perhaps will die anyhow when small, long before reaching maturity.

Ornamentals.—A number of plantings have been made in the vicinity of the buildings for ornamental purposes, nearly all of which proved incapable of surviving the rather vigorous climatic conditions. More extensive use of native flowering plants and shrubs is suggested.

Work With Livestock

Experimental work with livestock was commenced by the station in 1921. Feeding experiments, involving cattle and hogs were designed for comparing locally produced grains and forages. This work has covered many angles of the winter feeding and fattening problems. Contributions have included the successful finishing of hogs on rye alone and in combination with other grains, and the satisfactory use of winter rye and spring rye hay for maintaining cattle during the winter season. Development of different cattle types through the use of large and small type sires has also been demonstrated, and many points relative to the economic efficiency of these two classes have been and are now being worked out. The feeding of cattle on liberal and restricted planes of nutrition, with its subsequent effect on calves and mature animals has been in progress during the past ten years. Early work with dual purpose Shorthorns, certain of the results finding an application with reference to the small farm herd, were begun at the station in 1923, and later discontinued owing to restriction in operating funds.

The value of wheat as a fattening grain for hogs and cattle has also been demonstrated. The Montana plan of baby beef production was first tried, and several modifications of this method worked out by the North Montana Branch Station.

Grazing experiments designed to indicate the suitability of new forage plants and their carrying capacity, must go hand in hand

with crop production. The station as a preliminary step is also investigating various problems in range management on a 5000 acre tract in the Bear Paw mountain area. More work is also anticipated in connection with comparing various feeds grown under different methods of seed bed preparation, such as those produced on properly handled fallow and those grown under continuous cropping. The effect of time of harvest upon value of grain hays is likewise an open field. These are illustrations of where plant production and feeding investigations must be closely coordinated.

THE HUNTLEY BRANCH STATION

The Huntley Branch Station deals with investigations of problems in the production of both irrigated and dry land field crops and with experiments with dairy cattle. The work is in cooperation with the various interested Bureaus of the U. S. Department of Agriculture.

Irrigation Experiments

In the irrigated studies at the Station the principal line of work has been an extensive crop rotation experiment that has been under way since 1912 with the results of 25 years now available. Included in this experiment are 35 rotations varying from two to six years and also plots cropped continuous but with different treatments.

The outstanding features of this work are experiments with the value of alfalfa or other legumes and the use of manure in a rotation to maintain or increase productivity. In those rotations that include alfalfa during half the cycle of the rotation with the use of manure once in every four to six years, the original high yields have been maintained or increased. This is also true in some of the two and three year rotations when manure is applied directly to one of the crops in the rotation.

During the first 10 to 15 years of this work the use of alfalfa only as a soil enriching crop appeared to hold up yields of the other crops but in recent years there has been a very decided falling off in yields, particularly of sugar beets. In a rotation including three years alfalfa followed by potatoes, oats and beets, the average yields of beets for the first 18 year period was at the rate of above 13 tons per acre. During the last four years the average yield of beets in this rotation has dropped to less than 5 tons per acre. In

another rotation in which the kind of crops grown are identical but in which manure is applied preceding the beet crop, so that all of the land is manured once in six years, the yields of beets have been maintained uniformly at an average of more than 16 tons per acre during the entire 25 year period.

There is evidence in some of these rotations that treatments other than the use of alfalfa and manure will be required to maintain the soil productivity and that the soil would be benefitted probably by the use of phosphate and possibly other mineral additions.

The value of alfalfa, of manure and of commercial fertilizer in producing high yields has been demonstrated in a maximum crop production experiment. In this experiment a definite rotation of crops that include alfalfa is followed out. All crops excepting the grains receive a direct application of barnyard manure so that the land is manured in eight out of eleven years. Phosphate is applied directly to the grain crops and to sugar beets. The average yields per acre in this experiment over a ten year period have been as follows: Alfalfa 6.99 tons, corn 71.5 bushels, potatoes 472 bushels, oats 98.9 bushels, beets 21.72 tons, wheat 54.6 bushels and beans 48.3 bushels.

Other irrigated crop work has included tests of irrigated pasture grasses in which a pasture mixture was evolved that has a carrying capacity of from 1½ to 2 cows per acre over a 5 month period and has produced returns equal to or greater than returns from other crops.

After several years of experiments with Great Northern field beans good progress appears to have been made in selecting disease resistant and high yielding strains of this crop.

Tests of various crop varieties to determine their adaptability for this region are continually being carried out and recommendations made as to new varieties or crops.

Dry Land Experiments

Investigations in dry-land agriculture were begun at the Huntley Branch Station in 1912, and with the close of the 1936 crop year there were available the results of 24 years of uninterrupted experimentation dealing with the dry-farming problems of eastern Montana. This work has been under the direct supervision of the Division of Dry-land Agriculture, U. S. Department of Agriculture

acting in cooperation with other divisions of the Department of Agriculture, and with the Montana Experiment Station.

The principal lines of research have included the study of common field crops in their response to rotation and tillage practices; variety testing of grain, seed, garden and forage crops; determining the value of a number of annual and perennial crops for hog pasture; measuring the accumulation, penetration and depletion of soil moisture; and recording the climatic data influencing crop production.

As a result of the rotation experiments the proper place of fallow, corn and various small grains in a cropping sequence has been determined. The tillage investigations have shown the value of various methods of fallow and disked corn land as seedbed preparations for small grains; have demonstrated the futility of adding barnyard manure or plowing under crops for green manure in the hope of increasing yields or improving the condition of the soil, and have proved that deep plowing has given no larger crop returns than less expensive shallow plowing.

Crop variety tests have shown the superiority of Kharkof, Karmont, Marquis and Reward wheats, Marketon oats, Horn and Trebi barley, Northwestern Dent and Falconer corn, Great Northern beans, Cobbler and Triumph potatoes, Crested wheatgrass, Grimm and Ladak alfalfas and Sorgo and Sudan grass as forage crops.

The hog pasturing experiments have measured the carrying capacity of various crops and have demonstrated how a number of annual crops may be pastured consecutively so as to provide palatable grazing throughout the summer.

The soil moisture studies have indicated the tillage practices which will catch and hold the most precipitation and the degree of moisture withdrawn by the various crops. From the climatic record it has not only been possible to explain the seasonal behavior of crops but upon it may be built a program of dry farming procedure for the future.

Studies in Dairy Husbandry

Investigations concerned with the breeding, feeding and management of dairy cattle have been carried on without interruption since 1918. During this period of 18 years, a large amount of data has been obtained, both local and intersectional in value and appli-

cation. Many of the experiments are of such a nature as to require a number of years for completion.

One of the major experiments being carried on is the development of a strain of dairy cattle possessing a superior type of germ plasm. This is being accomplished by the use of proven sires and at the present time, the sixth consecutive proven sire is in service in the Station herd. The ultimate goal of this experiment is the development of a herd of dairy cattle pure in inheritance for those factors governing high milk and butterfat production.

Approximately 40 young sires, raised in the Station herd, are being tested at this time in the herds of cooperating farmers and dairymen. A total of 116 sires have been loaned since this Station started and records show that these bulls have sired 2681 daughters. Production records on the first 773 daughters of the first 73 sires loaned to these cooperating dairymen have been secured and the average mature production amounts to 11,203.2 pounds of milk and 406.86 pounds of butterfat, with an average per cent of 3.64 butterfat. The dams of these 773 daughters averaged 10,082.2 pounds of milk and 357.01 pounds of butterfat with an average test of 3.54 per cent.

Experimental data secured at this Station show that the feeding of roughage alone of high quality enables the dairy cow to produce milk and butterfat more economically than when grain is fed. One of the problems is the determining of methods whereby the quality of the roughage crops can be improved. Experimental data indicated that the quality of roughage is improved by harvesting the crop at a less mature stage. This results in a higher percentage of protein and a lower percentage of crude fibre. Cows fed either alfalfa hay alone, grass hay or grass silage made from pasture grasses at this Station have produced consistently about 400 pounds of butterfat annually.

Pasture grasses usually do quite well in most of the irrigated sections of Montana and in those sections of the State in which alfalfa does poorly, the dairyman can profitably substitute pasture grasses, not only as a grazing medium but as a good substitute for alfalfa hay or corn silage.

THE UNITED STATES RANGE LIVESTOCK EXPERIMENT STATION

The Montana Experiment Station has continued the cooperative work with the Bureau of Animal Industry, United States

Department of Agriculture, at the Range Station during 1936. The scope of work has been somewhat broadened as studies with swine were again undertaken and cross breeding experiments were inaugurated with the horses. A cooperative study on the carrying capacity of the range for beef cattle was worked out with the United States Forestry Service, while the Station Irrigation Department inaugurated a cooperative study on the effects of diversion flood waters and their control through contour ditches, on some of the range pastures. The major enterprise at the station continues to be with beef cattle and horses on the range. The station is now well equipped with farm buildings for the winter care of the breeding and the young stock.

The season of 1936 from the standpoint of grass and hay production was the worst in the experience of this station and this in spite of the fact that there was ample irrigation water for the farm hay lands. This was one of the driest and hottest years in the record, with very little growth on the range. What little there was and what was carried over from the year before was eaten off at the roots by a very heavy infestation of grasshoppers.

A good first crop of alfalfa was obtained but the grasshoppers destroyed any further crop by eating the leaves, stems, and growing buds off the plants as fast as they started to grow. The effect of the drouth and the grasshoppers, therefore, was to limit very seriously the feed supply for the livestock. This made it necessary to reduce the number of cattle from 879 as of September 30 in 1935 to 569 head in 1936, or by about 35 per cent.

Results from a Good Sire

To test the comparative value of two pure bred bulls, a feeding test for 322 days was carried on with steer calves sired by each bull. For 294 days of this period the calves were fed individually on alfalfa hay and wheat. The steer calves from one of the bulls showed significant superiority in final weight, in total gains, in average daily gains and in dressing percentage. There was, however, no apparent difference in efficiency of the gain or in carcass grade.

The female offspring from the two bulls were wintered on a medium plane of nutrition and for the summer carried on native range. When scored as calves and as yearlings, there was little or no difference in the two groups or in their total gains or average

weights as yearling heifers. The superiority of one of the bulls was shown in the more rapid gain of the steer calves and their better carcass grade. The purpose of this test was to find if it is possible to build a strain of cattle in which the superiority can be fixed and made dependably prepotent.

Russian Thistle as a Winter Feed

A plant that grows when nothing else will during periods of dry hot weather is the Russian thistle. With the usual kinds of feed very limited in 1936 a test was undertaken to measure the value of hay made from this thistle.

Of two groups of yearling heifers, during a winter period of 102 days, each heifer in one group received 4.24 pounds of alfalfa and 15.75 pounds of a mixture of thistle and straw daily, while the heifers in another group, during the same time, were fed 19.8 pounds of alfalfa hay daily.

The heifers fed the thistle gained 13.7 pounds during the winter and 81.4 pounds for the winter-summer period, while the heifers fed alfalfa only gained 72 pounds during the winter and 119 pounds for the full winter-summer period.

The heifers fed alfalfa only during the winter, at the end of the summer grazing season weighed 32.3 pounds more each than those fed thistles. However, charging the alfalfa at \$10.00 and the thistle hay at \$2.50 per ton, the cost per 100 pounds of gain was \$10.50 for the alfalfa fed heifers and \$8.06 for those fed thistles.

Carrying Breeding Cows on the Range with and Without Supplements

An important consideration most of the years, and especially during extremes of weather both winter and summer, for the range operation, is how to carry the livestock and especially the cows through the winter at as low a cost as possible and yet retain their health and keep losses at a minimum. To get some definite facts on one phase of the problem, two large groups of the cows at the range station were carried through five years, one group receiving a supplement of cotton seed cake and the other dependent only on the range pasture. The results from this test are given herewith.

The cows fed the supplement of cotton seed cake, maintained their weight during the winter and their calves were consistently heavier at birth and when weaned. Except for one severe

winter when 12 cows were fed hay for 43 days, all the cows fed cotton seed cake as a range supplement were maintained on the range all winter. When grass was scarce or covered with snow, they were vigorous enough to subsist on sagebrush, yucca, grease wood and other brush plants. Of the cows on the range without supplemented feed many of them, during the hard winters, had to be removed to the feeding lots to prevent winter losses.

A fact to consider, however, in weighing the results of this test is that the cost of the cotton seed cake was not fully repaid by the extra weights of the calves at birth or at time of weaning.

The results from the test showed conclusively that cotton seed cake made an excellent range supplement. It is a highly concentrated feed and can be fed on the range with little or no waste. The cows as a rule do not eat the cake readily at first so it is advisable to get them accustomed to it before the real need for it arises, or in other words before the cows get too thin to withstand the cold stormy weather.

For the practical stockmen, these tests suggest the culling out of the cows early in the season and through the winter when they show evidence of being run down and getting thin. Such cows should be kept together not too far from headquarters where extra feed may be readily available, and also when possible some shelter from the severe storms may be provided. In this there is nothing new. This test only measures more definitely the results of not following this practice.

Winter Feeding Costs

Breeding cows fed for the winter on a creek bottom and on upland brown range, together with 88 pounds of cotton seed cake each during 141 days, lost 57.7 pounds in weight. The same cows on summer range during 188 days gained a total of 1.6 pounds each and produced a calf weighing 71 pounds.

A similar group of cows fed 765 pounds of alfalfa each during the winter for 142 days lost 45.8 pounds each and during the summer period of 187 days on the range lost 17.6 pounds each and produced 87.6 pounds of calf per cow. The cows fed cake on winter range were stronger and more active at the close of the winter season than those fed alfalfa.

The wintering costs with cotton seed cake at \$33.00 per ton, hay at \$8.00 per ton and native range at 1 cent per head per day

was \$4.80 for each cow fed cake and \$6.33 for those fed hay.

PUBLICATIONS

The publications of the Experiment Station for the past year include twenty bulletins, two circulars, and fifteen technical papers. The bulletins and circulars were printed in editions ranging from 2,000 to 7,000 copies. With the annual report they make a volume of — pages.

The bulletins report the results of investigations carried on by the station staff. Many of the more technical reports are published in scientific journals. Since the last annual report the following publications have been issued.

Bulletins

No. 310. Readjusting Montana's Agriculture. IV, Land Ownership and Tenure. Roland R. Renne. 7,000 copies, 24 pages.

No. 311. Readjusting Montana's Agriculture. V, Economic Changes in Montana's Range Livestock Production. M. H. Saunderson. 7,000 copies, 30 pages.

No. 312. Oats and Dried Molasses Beet Pulp for Supplementing Alfalfa Hay in Winter Rations for Breeding Ewes. W. F. Dickson and Frank Barnum. 5,000 copies, 8 pages.

No. 313. The Cherry Aphid and Cherry Maggot of the Flathead Valley. 2,000 copies, 11 pages.

No. 314. The Virginia Creeper Leaf-Hopper. J. H. Pepper and H. B. Mills. 3,000 copies, 4 pages.

No. 315. Readjusting Montana's Agriculture. VI, Montana's Irrigation Resources. P. L. Slagsvold. 7,000 copies, 18 pages.

No. 316. Report on the Investigation of Phosphorus-Deficient Soils, 1935. Jesse R. Green and F. M. Harrington. 3,000 copies, 18 pages.

No. 317. Pea Vine Silage as a Feed for Dairy Cattle. J. O. Tretsvén. 3,000 copies, 11 pages.

No. 318. Readjusting Montana's Agriculture. VII, Montana's Dry-Land Agriculture. E. A. Starch. 7,000 copies, 19 pages.

No. 319. Readjusting Montana's Agriculture. VIII, Tax Delinquency and Mortgage foreclosures. Roland R. Renne. 7,000 copies, 28 pages.

No. 320. The Effect of Feeds on the Quality and Palatability

of Lamb. Jessie E. Richardson and W. F. Dickson. 3,000 copies, 19 pages.

No. 321. An Analysis of the Present Status of Agriculture on the Sun River Irrigation Project. P. L. Slagsvold. 3,000 copies, 60 pages.

No. 322. Montana Land Ownership. Roland Renne. 3,000 copies, 59 pages.

No. 323. Crested Wheatgrass in Montana. L. P. Reitz, M. A. Bell, and H. E. Tower. 5,000 copies, 54 pages.

No. 324. A Homemade Centrifugal Pump and Other Water-Lifting Devices. O. W. Monson and H. E. Murdock. 3,000 copies, 52 pages.

No. 325. Organization and Costs of Montana Schools. Roland R. Renne. 2,500 copies, 104 pages.

No. 326. Grazing Districts in Montana: Their Purpose and Organization Procedure. M. H. Saunderson and N. W. Monte. 4,000 copies, 39 pages.

No. 327. Volumes and Weights of Stacked Hay. H. E. Murdock. 3,000 copies, 22 pages.

No. 328. Types of Farming in Montana. Part I, Physical Environment and Economic Factors Affecting Montana Agriculture. Neil W. Johnson and M. H. Saunderson. 4,000 copies, 79 pages.

No. 329. A Study of the Trends of Montana Livestock Numbers, Prices, and Profits. M. H. Saunderson. 3,000 copies, 20 pages.

Circulars

No. 148. A Review of the Experimental Work with Phosphate in Montana, 1928-1935. Jesse R. Green. 7,000 copies, 16 pages.

No. 149. Judging the Age of Sheep by Their Teeth. Montana Veterinary Research Laboratory. 5,000 copies, 4 pages.

Annual Report

A Research Program: The Forty-Third Annual Report of the Montana Agricultural Experiment Station. F. B. Linfield. — copies, — pages.

Technical Papers

Germination of Crested Wheatgrass and Slender Wheat Grass. W. D. Hay. Proceedings of Official Analyst Association, Vol .10, No. 1, March, 1936. (Jour. Ser. No. 64.)

The Effect of Weight upon the Weaning Weight of Range

Lambs. W. F. Dickson and Frank Barnum. National Wool Grower, Vol. 26, No. 3, March, 1936. (Jour. Ser. No. 67.)

Probable Effects of Federal Land Purchase on Local Governments. R. R. Renne. National Municipal Review, Vol. 25, No. 7, July, 1936 (25:1-7) (Jour. Ser. No. 68.)

Experimental Vaccination of Range Calves: with a Living Culture of *Brucella Abortus*. W. J. Butler, D. M. Warren, and Hadleigh Marsh. Journal of American Veterinary Association, 89, n. s. 42, No. 2, August, 1936. (89:163-168) (Jour. Ser. No. 69.)

Observations Based on Weekly Parasite Egg Counts on Feces of Lambs and Yearling Sheep. Hadleigh Marsh. Journal of Parasitology 22:379-385, August, 1936. (Jour. Ser. No. 70.)

Rural Educational Institutions and Social Lag. R. R. Renne. Journal of Rural Sociology 1:3. Pp. 306-321. Sept., 1936. (Jour. Ser. No. 71.)

Oven Spring of Dough as Influenced by Sugar, Salt and Yeast. W. O. Whitcomb. Cereal Chemistry, Vol. 13, No. 6, Nov., 1936. (Jour. Ser. No. 72.)

Practical Suggestions for the Preparation of Standard Solutions for Protein Testing. W. O. Whitcomb. Cereal Chemistry, Vol. 13, No. 6, Nov. 1936. (Jour. Ser. No. 73.)

Further Studies with the Germination of Crested Wheatgrass. W. D. Hay. Proceedings of the 28th Annual Meeting of the Association of Official Seed Analysts of N. America. Read July, 1936. (Jour. Ser. No. 74.)

Thiodiphenolamie—a New Mosquito Larvicide. G. Allen Mail. American Association of Economic Entomologists, Dec., 1936. (Jour. Ser. No. 75.)

A Micro Colorimetric Method for the Determination of Nitrogen. William McKinley Martin. (Jour. Ser. No. 78.)

Laboratory Gas-absorption Vessels. William McKinley Martin. Industrial and Eng. Chemistry, 8:395, September 15, 1936. (Jour. Ser. No. 79.)

Weight Per Bushel of Wheat in Relation to Its Seed Value. W. O. Whitcomb. Proceedings of the Association of Official Seed Analysts of North America, 1936. (Jour. Ser. No. 81.)

Roughage vs. Roughage and Concentrates for Dairy Cows. J. O. Tretsven. Mimeographed. (Jour. Ser. No. 82.)

Accuracy of a Soil Termograph. G. Allen Mail. Soil Science,

Vol. 43, No. 1, January 1937. (Jour. Ser. No. 83.)

COOPERATION WITH OTHER AGENCIES

It has been possible during the past year to materially increase the work and service of the Agricultural Experiment Station through cooperation agreements with outside agencies. Most important of these have been with the United States Department of Agriculture. Such agreements have been in operation with the Bureau of Plant Industry and its divisions of Dry Land Agriculture, of Cereal Crops and Diseases, of Forage Crops and Diseases of Western Irrigation Agriculture, and of Barberry Control, also with the Bureau of Animal Industry through the Animal Husbandry Division in studies carried on at the United States Range Livestock Experiment Station near Miles City, Montana, with the Bureau of Agricultural Economics, Division of Farm Management and Cost and the Division of Land Economics, with the Forestry Service and with the Soil Conservation Service, with the Bureau of Chemistry and Soils, with the Bureau of Entomology and Plant Quarantine, and with the Bureau of Dairying.

The Montana Experiment Station has also been working in this state in close cooperation with the Federal Agricultural Adjustment Administration and the Resettlement Administration, while the Farm Credit Administration and the Federal Land Bank have made available to the Station many facts valuable in analyzing the agricultural situation in Montana.

It was possible during the year to increase greatly the studies of many economic and social facts and problems and also to continue the analysis of county and state costs and services, through the employment of additional help made possible by funds provided by the Works Progress Administration and made available to this station through their Montana office.

THE STATION STAFF

There have been several changes in the Experiment Station Staff as compared to that given in the last Annual Report. E. A. Starch was made Head of the Department of Agricultural Economics but was on leave for most of the year.

Resignations from the Station were: A. L. Mimms, Assistant Agricultural Economist; L. P. Reitz, Assistant Agronomist; W. F.

Dickson, Associate Animal Husbandman; Frank Barnum, Assistant Animal Husbandman; Chester S. Funk, Assistant in Chemistry; G. W. Morgan, Superintendent of North Montana Branch Station and J. E. Norton, Superintendent of Judith Basin Branch Station.

Those added to the staff include: Phillip S. Eckert, Assistant in Agricultural Economics; William B. Nelson, Assistant in Agronomy; A. H. Walker, Assistant Animal Husbandman; R. E. McCall, Assistant Animal Husbandman; K. J. Goering, Assistant in Chemistry; V. E. Iverson, Assistant in Horticulture; M. Afanaseiv, Assistant Botanist; Anne Nechanicky, Assistant in Veterinary Research Laboratory; M. A. Bell was made Superintendent of the North Montana Branch Station and J. L. Sutherland, of the Judith Basin Branch Station.

FINANCIAL SUMMARY

EXPENDITURES OF THE MONTANA AGRICULTURAL EXPERIMENT STATION FOR THE YEAR ENDING JUNE 30, 1936

	Hatch	Adams	Purnell	Bankhead Jones	State and others*
Salaries	\$ 7,583.65	\$10,010.85	\$32,236.43	\$1,633.86	\$ 56,847.65
Labor	2,502.19	2,210.50	16,750.22	1,618.47	19,228.03
Stationery and Office	730.14	9.05	774.76	2.25	2,579.79
Scientific, consumable	138.58	653.08	1,085.64	53.08	1,249.72
Feeding stuffs	123.98	—	959.08	114.80	10,056.29
Fertilizers	—	—	120.81	31.88	359.67
Sundry	207.27	62.26	369.64	28.34	8,606.61
Communication service	542.56	2.27	107.14	—	797.20
Travel expenses	276.60	872.25	3,294.85	133.02	1,962.38
Transportation of things	48.32	1.39	39.25	6.26	201.47
Publications	1,733.71	—	1,581.14	—	814.84
Heat, light, water, power	10.59	—	239.07	—	3,743.97
Contingent expenses	15.82	4.90	0.82	—	113.16
Furniture, furnishings and fixtures	348.43	342.07	617.29	—	128.98
Library	296.80	17.90	144.30	—	78.95
Scientific equipment	127.40	691.15	255.13	—	198.50
Tools, machinery, appliances	279.32	72.33	1,033.45	157.58	278.16
Livestock	23.00	—	261.80	96.25	2,646.05
Buildings and land	11.64	50.00	129.18	—	594.31
Totals	\$15,000.00	\$15,000.00	\$60,000.00	\$3,875.79	\$110,485.73

*This fund includes the following:

State appropriations for Home Station	\$46,696.08
For Grain Laboratory and Branch Stations	25,648.75
Income from sales	38,140.90